

A GEOCHEMICAL STUDY OF ACID MINE DRAINAGE AT THE SIA MINE, CYPRUS.

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One of the many abandoned massive sulphide mines of Cyprus is located at Sia, approximately 25 km south of Nicosia. Atmospheric precipitation interacting with sulphide minerals in exposed ore, tailings and waste tips of the open-pit produces run-off with pH's as low as 1.5. This run-off has produced a permanent lake of approximately 40,000 cubic metres occupying the open pit, and forms the main reservoir of the hydro-logic system. The pH of the lake water averages 2.0, and the electric conductivity can be as high as 40000 us/cm, but there are marked seasonal variations. Trace element concentrations are invariably raised in the acid mine drainage. The lake water drains both through the groundwater system and as surface waters in a stream which eventually flows into a catchment dam, where it is distributed for irrigation. Since groundwater is a major resource, there is also potential for contamination of water for animal and even human consumption.

The physical environment of the mine waste including sulphide and gangue mineralogy and grain size, microbial activity, pH of water, oxygen fugacity, temperature and humidity are the major factors affecting the reactions which oxidise the sulphide minerals. Solid and water samples throughout the whole system have been sampled and analysed by XRF, XRD, ICP-MS and other methods. A number of key elements have been traced throughout the system and show significant variation in its component parts. These include Na, Mg, K, Ca, Al as well as Cl^- , SO_4^{2-} , HCO_3^- , CO_3^{2-} , NO_3^- , CaCO_3 , Cu, As, Cd, Zn, Mn, Si, Fe, Ni, CN^- , Pb, Co, Ti, and Ba. pH and EC have been recorded throughout the system.

The production of acid mine drainage and the accompanying concentration of trace elements results from three series of reactions, sulphide oxidation, dissolution of carbonates, and reactions involving gangue minerals. Oxidation of the sulphides produces secondary hydrated sulphates and oxi-hydroxides, the most predominant of which are gypsum, jarosite and goethite. There are minor amounts of secondary native sulphur thought to result from pyrrhotite oxidation. Those secondary salts with low solubility (alunite-jarosite group) have relatively little effect on the water chemistry because they dissolve only slowly. More soluble salts precipitated on the lake margins in the dry season, lock-up concentrations of toxic elements.

These are subsequently released by rapid dissolution of these salts in periods of high precipitation. There are thus marked seasonal variations in water chemistry. Dissolution of carbonates appears to add Ca, Mg, and Mn to the water but also mitigates the effects of reduced pH. At a distance of several hundred metres from the mine lake, groundwaters can show almost neutral acidity, whilst surface waters maintain low pH values, up to distances of 5km. High concentrations of Si and Al appear to be derived from gangue mineral reaction, particularly the weathering of aluminosilicates, and the reaction of plagioclase in the basaltic host rocks at pH's below 4.6.

Grain size and surface area considerations indicate that the tailings and waste dumps are the greatest source of contamination and it would seem that there is potential for significant improvement in water quality either by rendering them impervious, or moreso through their complete removal.